"ROLE OF ULTRASONOGRAPHY IN PRENATAL DIAGNOSIS OF IUGR AND A STUDY OF ETIOLOGICAL FACTORS AND PRENATAL RISKS IN SYMMETRICAL AND ASYMMETRICAL IUGR"

THESIS

FOR

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1991 RITTU MALHOTRA

CERTIFICATE

This is to certify that the work entitled "ROLE OF ULTRASONOGRAPHY IN PRENATAL DIAGNOSIS OF IUGR AND A STUDY OF ETIOLOGICAL FACTORS AND PERINATAL RISKS IN SYMMETRICAL AND ASYMMETRICAL IUGR", which is being submitted as a thesis for M.S. (Obstetrics & Gynaecology) by DR. RITTU - MALHOTRA has been carried out under my direct supervision and guidance in the Department of Obstetrics and Gynaecology, M.L.B. Medical College, Jhansi.

She has put in the necessary stay in the department as per university regulations.

Dated_____, 1990

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Ritu Malhotra

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I N D E X

ABBREVIATIONS USED

BPD	-	BIPARIETAL DIAMETER
HC	-	HEAD CIRCUMFERENCE
AC	-	ABDOMINAL CIRCUMFERENCE
FL	-	FEMUR LENGTH
GA	-	GESTATIONAL AGE
SGA	-	SMALL FOR GESTATIONAL AGE
LBW	-	LOW BIRTH WEIGHT
IUGR	-	INTRA UTERINE GROWTH RETARDATION

INTRODUCTION

I N T R O D U C T I O N

Ultrasonography, because it is safe, non invasive, has become the principal means for obtaining the morphological information about intrauterine structures. With this procedure, the contents of the uterus as well as the internal structure of placenta, foetus, foetal organs can be evaluated at any time of pregnancy.

The principal of ultrasound is based on the piezo-electric effect, direct and converse. This requires a transducer which is made of piezoelectric cyrstal converts electric energy into sound waves. Only certain materials, initially quartz but now a days barium tetanate or lead zirconate have piezoelectric properties when cut as crystals along certain given axes.

Echoes are generated whenever an ultrasonic beem in its passage through the body encounters a boundary or interface between 2 different types of tissues. Every tissue in the body has its own specific acoustic impedence which is the product ofthe speed of sound wave passing through it and the density of that tissue (P) The greater the difference in the acoustic impedence of the tissues on either side of an interface, the strong will be the echo. The sound waves which are reflected at every interface between tissues of different densities, are them picked up by the same

transducer, reconverted into an electric current which is then displayed on an oscilloscope. Pioneer work on ultrasound in obstetric was done by Ian Donald (1965). Ultrasound has a higher frequency (20 kilo hertz) than man's hearing range (20-20000 hertz). The frequency of diagnostic ultrasound ranges from 1-9 million hertz. Accurate determination of gestational age is essential in the care and management of pregnant patient. Information on gestational age allows one both to date the pregnancy and to distinguish normal from abnormal growth patterns. The use of diagnostic ultrasound has made it possible to observe foetal growth in utero and the foetal growth parameters allows one to evaluate objectivly the growth process. A complete evaluation of the foetus can be achieved with the use of a sonographic foetal growth profile which consists of measurement of head size, trunk size, femur length, estimated foetal weight and body proportionately.

There has been an increasing concern over the discrepency between gestational age and expected weight of foetus at birth. In recent years more attention has been directed towards measuring the physical and intellectual potential of off springs. One of the greatest threats to this is IUGR.

IUGR is conventially and statistically defined as infant falling below 2 SD of the mean or between the third percentils in weight for gestation.

Babies of IUGR are not a homogenous population and atleast 2 morphological groups are distinguished. The severity of retarded foetal growth depends on the etiology, duration and degree of the IUGR process. If a severe insult begins early in the first trimester of pregnancy, the foetus is proportionately small in all parameters and the case is therefore, referred to as symimetric IUGR. The typical causes of this form of IUGR include -

a) a low genetic growth potential,

b) intra-uterine infection,

c) severe maternal malnutrition,

d) chromosomal abnormalities and

e) severe congenital anaemia.

On ultrasound all the parameters of growth profile are decreased. If the IUGR process begins in the late 2nd or early 3rd timester, there is a typical relative sparing of the foetal head size andbbody length in comparision with foetal soft tissue mass and weight. This form of IUGR is referred to as asymmetric IUGR and is usually the result of placenta unsufficiency. If this process is undetected and grows to term, the

foetal head size and body length will ultimately be affected and the foetus will become more symmetrically growth retarded. On ultrasound BPD shows late flattening growth pattern with decrease in incremental growth, only towards end of gestation. FL growth pattern is similar to BPD while AC gets affected earlier and is decreased.

The etiological mechanism, perinatal risks and long term prognosis appear to differ in the 2 groups and it would be of great use in a reliable antenatal means of distinguishing between them could be found.

Several large studies have established that IUGR babies can have a 3-10 fold increase in perinatal mortality when compared to infants whose weights are appropriate for gestational age. IUGR babies are subject to numerous problems during the immediate postpartum period such as intrapartum asphyxia, neonatal hypoglycemia, acidosis, hypocalcemia and polycythemia. Those who survive may develop neurological abnormalities in later life. For these measures, it is imperative that the diagnosis of IUGR be made in utero so that foetus can be removed from its environment at an appropriate time and will give a higher chance of survival and lowest risk of adverse sequaelae.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Intrauterine growth retardation - is an important entity and goes by a variety of names including small for date, dysmaturity, chronic malnourished foetus, undergrown foetus and placental insufficiency. Clifford (1954) described and classified the appearance of the so called dysmature infant.

IUGR has been traditionally defined if -

1. the birth weight of the foetus falls below the 10th percentile of appropriate gestational age.
2. below 2 SD from mean values of birth weight for gestational age.
3. growth deficient of 4 weeks or more at a particular gestational age during pregnancy.

For the diagnosis of IUGR it is imperative that correct gestational age be defined. Gestational age determined accurately allows one to both date the pregnancy and to distinguish normal from abnormal growth patterns. The patients inability to recall LMP correctly, the use of oral contraceptives, lactation, obesity, uterine myoma, the subjective nature of maternal reporting of quickening can all confuse the clinicians estimate of gestational age.

ESTIMATION OF GESTATIONAL AGE

Because of irregular menstrual cycles, a significant number of patients will not recall their LMP.

Hertz et al (1978) reported that only 18% of patients were able to reliably give the dates of their LMP.

Wenner and Young (1974) suggested the figure to be 33%.

Junenez et al (1983) reported the appearance of foetal heart tones by foetoscope at 17.1±1.1 wks and fundus reached the umbilicus at 16.6±0.9 wks. At 29-31 wks fundal height in cm/equalled gestation in weeks.

Gestational age can be estimated by :

<u>Clinical</u>

1. L.M.P.
2. B.B.T. - It has a variability of 2-3 week (Bowie et al) ovulation occurs within 36 hr of rise of BBT and implantation within a week.
3. Quickening 18-20 weeks.
4. First trimester P/V
5. Fundal height
6. FHS - Doppler - 14 weeks
   Foetoscope 18 weeks

<u>Biochemical</u>

1. L/S ≥ 2 - with gestation less than 34 weeks
   < 2 - gestation more than 38 weeks (Deter et al, 1982).
2. Phosphatidyl inositol - appears at 30 weeks and declines by 35 weeks.
3. Shake test

4. Nile blue sulphate test - If more than 20% orange coloured cells implies GA of 36 weeks.

5. Creatinine in liquior amnu - 2 mg/100 ml indicates maturity.

6. Enzyme assay - Oxytocinase and alkaline phosphatase level in maternal plasma.

Roentgenogram

1. Distal femoral epiphysis - Ossification centre appears between 32 - 38 weeks.

2. Proximal Tibial Epiphysis - Ossification centre appears between 33-41 weeks.

Ultrasound

1. Gestational sac
2. Crown-rump length (CPL)
3. BPD - Single/serial/GASA
4. Fronto-occipital diameter (FOD)
5. Head circumference (HC)
6. Head Area (HA)
7. Thoracic diameter (TD)
8. Thoracic circumference (TC)
9. Thoracic area (TA)
10. Abdominal circumference (AC)
11. Abdominal diameter (AD)
12. Abdominal area (AA)
13. Femur length
14. Multiple fetal growth parameter (MFGP)

15. Placenta

16. Morphological

Relative size of fetal ventricle, appearance of choroid plexus, echogenicity of foetal lung, appearance of foetal bowel, appearance of foetal kidney.

Appearance of foetal skin,

thickness of thigh.

17. Dynamic events

A- -Fetal breathing movements - short bursts of 4-10 min (20-28 weeks).

Longer episodes (28-30 weeks).

-Multiple short respiratory efforts with long period of expiration (30-34 weeks).

-More even ratio of respiration to expiration 36-39 weeks.

B- Others

Individual limbs flexion/extension

Trunk movements

Chest wall movements

Diaphragm movements

Foetal eye movement

Foetal mouth and tongue movement

Bowel peristaltic movement

1. Gestational sac diameter

This is the first evidence of intrauterine pregnancy seen at 4½-5 weeks after last menstrual period. Gestational sac is seen before the foetus is seen. Hellman et al (1969) has suggested linear measurements of gestational sac be utilized as a sign of gestational age. However, when a single internal diameter of the sac or an average of 2 or 3 diameters is used for determination of gestational age, the variation for 90% of cases is approximately ± 2-3 weeks. Therefore gestational sac mean diameter has not routinely been employed for estimation of gestational age.

Measurements of sac area and volume have proved more time consuming with no improved accuracy.

2. Crown rump length

This is the measurement of the largest dimension of the foetus. This can be measured at 6½-7 weeks gestation and pregnancy can be dated to within 4-5 days. It can be detected until 14 weeks of gestation. Robinson et al (1975) have shown in cross sectional studies that the CRL increases parabolicly with gestational age.

Nelson (1981) measured CRL in 83 normal pregnant women and devised a linear regression formula

GA = 51.008 + .6CRL
(days)
(r = 0.928)

3. Biparetal Diameter

Single

Serial

Growth adjusted sonographic age (GASA)

Early studies of BPD were limited by poor resolution of the equipment and differences in scanning and imaging techniques as well as by assumptions about different tissue velocities. Recent advances in imaging have permitted guidlines to be established for imaging and measuring the BPD in a more consistant fashion. BPD was first measured by Donald and Brown in 1961.

After 12 weeks the measurement of BPD is an excellent means of estimating GA because there is a close correlation between BPD and GA and moreover is subject to little error. Various studies (Campbell and Neuman 1971, Queenam et al, 1976, Sabbagha, 1978, Arora 1979, Kurtz, 1980 and Mini et al 1983) have suggested that the BPD increases in a linear fashion to approximately 30 weeks after which the growth rate slows progressively reaching a plateu near time.

Campbell et al measured BPD in 170 normal pregnant women between 20-30 weeks and reported a variability of ± 9 days. They also reported BPD growth between 20-30 weeks as 2.8 mm/wk and after 30 weeks it decreases to 1.5 mm/wk. The standard error of measurement of BPD is

2-3 mm. Therefore the more advanced the pregnancy, less reliable is the dating by BPD.

Kopta et al found that in 27 patients between 12-20 weeks, the mean error in predicting the actual date of delivery by CRL was 7-13 days as opposed to 7.65 days by BPD.

Smozel et al showed that 2nd trimester BPD measurement is as accurate as the first trimester CRL in establishing the BPD.

Some investigations have suggested that serial BPD measurements will improve the accuracy of dating. However the study of Brein et al (1980) showed that more then one BPD did not add to the accuracy of EDD prediction. If serial cephalometry is used approximately the distinction between large and small BPD's becomes possible, thereby refining assessment of foetal age.

Sabhagha described another method for prediction of EDD known as GASA (Growth Adjusted Sonographic Age). He claimed an accuracy with 95% confidence limit of 1-3 days. He measured BPD first at 26 weeks and again at 33 weeks. On the basis of evaluation of the head growth and interval between the scans, he adjusted the original assigned gestational age if the head growth was greater or less then expected.

Simon et al in 1984 conducted a study on 248 patients. Single BPD measurement was made between 18-26 weeks and temporarily accepted (accuracy ±11 days) BPD was repeated at 30-33 weeks and BPD was assigned to one of the 3 growth patterns :

1- Small	25th percentile
2- Large	75th percentile
3- Average	25-75th percentile

If second BPD is in small category add 7-11 days to the previous GA obtained by the first BPD reading.

If the second BPD is in the large category subtract 7-11 days (AD-10 days). The accuracy was reported as ±1-3 days.

Smazel et al have shown that GASA dating is no more accurate than a single BPD measurement taken at 20-24 weeks. The sole reliance on BPD for estimation of GA is now passing. It can lead to serious error and clinical management.

4. <u>Fronto-occipital diameter</u>

Levi et al (1975), Deter et al (1982) have correlated this parameter to the gestational age in weeks.

FOD = -78.6+9.31 GA-107$(GA)^2$ Levi (1975)

FOD = .676+3.42(GA) Deter (1981)

FOD = - .572+333(GA) Jordon (1978)

5. Head circumference

Prenatal moulding of the foetal skull is a common occurance in pregnancy (breech, twins). Hadlock et al (1982) has shown that head circumference is a better predictor of menstrual age than BPD in the last week of pregnancy.

The cephalic Index (CI) that is ratio between size of BPD + FOD taken from same picture, multiplied by 100 expresses CI as % age (78.3±4.4). If it is significantly above or below normal, head circumference should be used instead of BPD for estimating GA. It can be measured by electronic calipers or by the formula.

$$HC = \frac{\pi}{2}(BPD + FOD)$$

Hoffbauer et al (1979), Wittman et al (1979), Deter et al (1982) reported variability of ± 1.5 to 2.5 cm at 28 weeks gestation. Law and Mac Roe reported HC to be more accurate than BPD.

6. Head area

Garriett and Robinson (1971), Levi (1975), Wittman et al (1979) and Varma (1979) have considered it as a growth parameter. Growth is reported to be rapid upto 35 weeks and growth then decreases upto 40 weeks.

7. Thoracic diameter

Levi and Erbsmann (1975), Issel et al (1975) and Hoffbauer et al (1979) have considered this as a parameter for estimating GA. It is an anteroposterior

diameter of the chest. It has a disadvantage in that the place at which measurements are made have no well defined landmarks and hence lack reproducibility.

8. Thoracic circumference

Levi and Erbamann (1975) and Hoffbauer et al (1979) have measured chest circumference at different gestational ages.

$TC = 12.7+1.82\ (GA) - 1.71X10^{-2}(GA)^2$ -(Levi 1975)

9. Thoracic area

Changes in the chest profile area as a function of gestational age has been determined by Levi and Erbaman (1975) and Varma (1979). This parameter shows a rapid linear growth upto 37 weeks at the rate of 2.4 cm^2/wk and a decreased rate upto 40 weeks.

$TA = 31.2+2.85\ (GA)$ (Levi 1975).

10. Abdominal circumference

AC is a linear function of GA (Deter et al 1982) it can be measured by electronic calipers or by the formula

$$AC = \frac{\pi}{2}\ (AP + \text{Transverse diameter})$$

Campbell and Wilkens (1975), Warsoff (1977), Wittman et al (1979), Sabhagha (1979), Hoffbauer et al (1979), Deter et al (1981) have reported the use of AC for evaluating GA and foetal growth. Because of occassional rapid growth of abdominal circumference

late in pregnancy the relationship of abdominal circumference to GA is less reliable than BPD. Selbing (1986) reported that the use of mean abdominal diameters was as reliable as foetal femur length in GA assessment.

Unlike the head measurements there is no constant relationship between transverse and AP abdominal diameter, since fetal respiratory movements can alter significantly the relationship between these 2 diameters. Hadlock et al pointed out that predicting GA from AC measurements indicates that it is actually a worse predictor of GA than BPD except during the interval 36-42 weeks at which time it can be accurate.

In IUGR and macrosomia, the use of AC will either falsely reduce or raise the GA respectively.

11. Abdominal diameter

Garrett and Robinson (1971) have measured transverse diameter in 50 patients between 23-36 weeks. Hoffbauer et al (1979) also determined the abdominal diameter, but no significant conclusions were drawn by either.

12. Abdominal area

Garrett and Robinson (1971), Waldimiroff et al (1977), Wiltman et al (1979) and Varma (1979) have shown that there is a linear increase in the profile area as a function of GA.

13. Femur length

Of all bones of the body , femur length is the easiest to perform. Humerus is more difficult to define accurately because of its proximity to the chest wall and apparent continuty with scapula and clavicle. Also when flexed the radio-ulnar complex lies nearer to the humerus than the tibia.- fibular complex when flexed to the humerus. Radius, ulna, tibia, fibula can only be measured as a complex.

Femur length can be identified as early as 10 weeks of gestation. Gregory et al demonstrated that FL grows initially at 3.15 mm/week and slowly decreased to 1.55mm/week towards 3rd trimester.

The variability with predicting GA with FL measurements according to Hadlock's et al is ± 9.5 days between 12.23 weeks and ± 22 days between 23-40 weeks.

Brien et al stated that GA could be predicted with 95% confidence limit of ±6.7 days in 25-35 weeks.

Hadlock et al and Hohler and Quetal reported a variability of ± 3-3.5 weeks.

The length of foetus so determined in utero adds another parameter that could be used in evaluation of different foetal growth patterns. The peak foetal growth is around 20th weeks whereas weight growth is pre-dominantely a phenomenon of 3rd trimester.

Therefore FL determination could be used to investigate the timing factor in the pathophysiology of IUGR.

14. Multiple foetal growth parameters method

Hadlock and Deter first proposed this method of averaging the estimation of age based on BPD, AC, HC and FL. This was later developed by Kopta et al (1981).

Additional foetal measurements averaged together with BPD measurements improved the precision of pregnancy dating. Advantage of this method is that abnormality of body symmetery or proportion become quite obvious.

15. Placental grading

Ultrasound of placenta at different gestational ages showed grade I changes at 33 weeks grade II at 35.5 weeks and grade III around 39.9 weeks

Section of placenta	Grade 0	Grade I	Grade II	Grade III
Chronic plate	Straight and well defined	Subtle undulations	Indentations extends to placenta but not to basal layer	Indentations extending to basal layer
Placenta substances	Homogeneous	Few scattered echogenic agas	Linear coma like densities	Circular densities with echospared areas in centre
Basal layer	No densities	No densities	Linear arrangement of small echogenic areas (basal stippling	Large and somewhat confluent basal echogenic basal densities can create accoustic shadows

IUGR

Once the gestational age is ascertained, foetal growth can be defined as time dependent increases in specific geometrical characterestics of the foetus. With ultrasound many of these parameters can be evaluated in the prenatal period. If growth parameters do not change as expected one suspects that IUGR has occured.

Usher, Maclean and Greunwald defined IUGR as birth weight more than 2SD below the mean birth weight. Earlier attempts, to define IUGR by Albermann and Butter (1969) as birth weight has been 2.51 kg does not necessarily imply IUGR as it does not take GA into account. Criteria used in the prenatal detection of IUGR by different investigators is given as follows :

Campbell — BPD growth rate below 5th percentile.

Whetham — BPD below 2 SD at any time.

Crane — BPD below - 2 SD with normal growth rate.

Subhagha — BPD growth rate between 26 weeks and 30-33 weeks below 25th percentile.

Arias — BPD growth rate below mean for gestational age.

Persson — Single BPD below 5th percentile at 32 weeks.

Crane — Single BPD below - 2 SD. Serial BPD's below -2 SD during 3rd trimester.

HC/AC above 95th percentile using the normal values published by Campbell and Thomas.

Varma — HA/TA and AA below 2 SD at 33 weeks.

HA/TA and HA/AA above 2 SD at 33 weeks

HA/TA and AA below 2 SD 10 days before delivery.

Campbell — HC/AC above 95th percentile within 7 days of delivery.

Wladimiroff — $(BPD)^2/AA$ above 95th percentile.

Deter — One or more HC/AC above 95th percentile using the normal values published by Campbell and Thomas.

Wittman — Single BPD, TA, CRL and CRLXTA below 10th percentile.

Kujak — Single BPD, BPD growth rate or AC or HC/AC below 10th percentile.

Lubchenco's (1966) defination which defines IUGR as birth weight below 10th percentile has problems in specificity. First because of statistical distribution of foetal weights in a general population atleast 7% of normal babies will be classified as growth retarded when 10th percentile is used to differentiate normal and abnormal featuese. Secondly it does not take into account growth retarded foetuses whose birth

weight falls above the 10th percentile line. Indeed it is now known the fetuses affected by IUGR are not a homogenous population and that varying degree of compromise in height, weight and soft tissue mass can be observed.

Decreased length, head circumference, loss of adipose tissue and muscle mass as well as decreased organ weights have been associated with IUGR. However recent studies have shown that these findings are not always associated with LBW. This indicates that growth retardation has more than one form and hence more than one parameter may be required to identify all affected fetuses.

The severity and type of IUGR process depends on the etiology and duration of insult. If a severe insult begins early in the first trimester of pregnancy, the foetus is proportionately small in all parameters and the case is of symmetric IUGR. The common etiological factors are :

1. Congenital anomalies.
2. Quality of maternal and foetal genome.
3. Infection, drugs.
4. Smoking and
5. Maternal malnutrition.

On ultrasonic examination, the growth pattern is characterised by a BPD that grows consistently slower

than normal atleast after the 20th week. Comparisions of head and trunk growth have revealed a disproportionate decrease in trunk growth in 40% of the cases in a study of 10 cases by Campbell (1977). This growth retardation is also called the 'Low Profile' and has poorer prognosis.

If the IUGR process begins in the late 2nd or early 3rd trimester, there is a typical relative sparing of the foetal head size and body length in comparision with foetal soft tissue mass and weight due to adaptation and maintaining blood flow to brain, heart and adrenal.

This is due to :

1. Placental insufficiency and
2. Multiple gestation.

On ultrasonic examination 'Late flattening' can be detected by serial measurement of the BPD. The BPD is within normal range until 30th week of gestation when its rate of growth shows or stops. Comparisions of head and trunk growth have revealed a disproportionate decrease. Campbell in 1977 and Crane (1979) in a study of 19 and 7 foetuses respectively have shown a decrease in 84.2% and 100%. This is called asymmetrical IUGR. It has a better prognosis.

Campbell has shown that 70% of foetuses have asymmetrical and 30% have a low profile IUGR.

Hadlock et al have found 80% of growth retarded to be asymmetrical and 20% in symmetrical category.

Sabbagha however has find that in 67% of SGA babies abnormally slow BPD growth before 30-32 weeks while 33% have normal BPD growth.

Wladimiroff's study of 84 SGA babies indicated 22.6% had normal head and trunk diamensions, 2-3% had small heads and normal limbs, 34.5% had normal heads and small trunks and 40.5% had small heads and small trunks.

Usher and Maclean and Yerushalmy (1971) have shown that perinatal mortality is 8 fold increased in IUGR. It accounted for 25% of the prenatal mortality, rate. These factors are also subjected to intrapartum and neonatal asphyxia (Low et al), hypoglycemia, hypoglycemia, polycythemia (Bard 1971), Meconium aspiration, pulmonary haemorrhage, disorder of temperature regulation, congenital malformation, long term morbidity in the form of impaired motor and cognitive function, lower IQ and neurological abnormalities are increased upto 20% (Werner 1970).

Gallrith et al have shown 14.4% of mentally retarded children to have suffered from IUGR at birth. Fitzharding and Stevens have shown 40% of IUGR infants to have difficulty in school, 20% of still births are growth retarded. Earlier the insult

longer the exposure, poorer the prognosis.

DIAGNOSIS OF IUGR

The most important for detecting IUGR in utero is the identification of women who are at risk of delivery of a growth retarded foetus since according to Hadlock et al (1983) 2/3rd of all IUGR foetuses will come from this population.

The most important characteristics of this population are a history of previous growth retarded foetus, chronic hypertension, severe insulin dependent diabeties mellitus, extremely poor weight gain, alcohal or drug abuse and heavy smoking. But 1/3rd of all IUGR foetuses will be born to patients with no high risk factor for IUGR, hence one should analyse the foetus for evidence of IUGR in all obstretic sonograms, regardless of reason of study.

The use of diagnostic ultrasound has made it possible to observe foetal growth in utero and a number of foetal growth parameters allow us to objectively evaluate the growth process. A complete evaluation of the foetus can be achieved with the use of sonographic growth profile which consists of measurement of head size, trunk size, femur length estimated foetal weight and body proportionality.

Time of doing the sonographic examination is important. Many of the growth parameters used to

detect IUGR will not become abnormal until 30 weeks particularly in cases of asymmetrical IUGR. Thus normal examination results in a high risk patient at 28 weeks do not preclude the possibility of IUGR at 32 weeks and in high risk patients it is preferred to examine the patient every 4 weeks until delivery. If IUGR is found, the interval between scans is reduced to two weeks.

Prenatal diagnosis of IUGR can be done by :

1. Abdominal palpitation
2. Ultrasound
3. Serial determination of 24 hour urinary estriol excretion.

The detection of IUGR by clinical means alone is difficult and subjected to a wide range of error. Daiko (1979) conducted a study on 70 high risk pregnancies for detection of IUGR. He found that antenatally some factors may be significantly predictive of IUGR, yet demonstrate definative diagnostic dilemma.

Maternal weight gain less than 2 lb/wk was noted in 64% of IUGR but was also noted in 36% of normal growth pregnancies.

Reduced fundal growth less than 2 cm/wk was present in 1/3 of all cases and 64% of IUGR cases demonstrated this but 25% of normal growth pregnancies also manifest this.

Klopper (1970) found estriol estimation in IUGR patients of limited value. However Low et al (1973) found low estriol levels associated with IUGR pregnancies but in 13% of IUGR cases had estrogen less than 30% of the normal mean. Also many normal weight new borns had estrogen indices in the IUGR range.

A low estrogen/creatinine ratio was found by Daiko (1979) in IUGR but not in normal patients and may be more useful.

ULTRASOUND MEASUREMENTS IN IUGR

Foetal growth has been assessed by ultrasound using the following growth parameters.

1. Biparietal diameter

The foetal BPD was the first parameter used by ultrasound for detection of IUGR. Detection by this measurement was proved unsatisfactory. First in the majority of fetuses affected by IUGR, foetal head size is spared until the third trimester of pregnancy and does not usually fall outside the normal range until near term. Thus the use of this measurement alone will result in a very low sensitivity with a high number of false negative results. Secondly variations in foetal head shape due to moulding particularly the dolichocephaly which is observed in cases of foetal crowding (e.g. ruptured membrane, twins, breech foetus) will result inabnormally low values in normal foetuses with

a high number of false positive cases of IUGR.

Nelson (1980) and Wittman (1979) found BPD measurements to have specificity of 56-59% while Kurjak et al (1980) reported specificity of 48.6% in diagnosing IUGR.

Seeds et al (1989) reported an accuracy of 43-100% and Sebling (1984), Campbell (1971) Whetham (1976) found serial BPD to have an accuracy of 70-73% in detecting IUGR.

Queenan et al (1976) studied 100 high risk patients and found two patterns of IUGR.

Sabbagha (1978) used the GASA method to detect IUGR in 463 high risk patients. He found :

a) 75th percentile - 3.5% had IUGR (asymmetrical)

b) 25-75th percentile - 3.5% had IUGR(asymmetrical)

c) 25th percentile - 52.1% had IUGR(symmetrical)

d) Decreasing BPD - 20% had IUGR (symmetrical)

2. <u>Head circumference</u>

It is well known that head circumference is a more shape dependent measurement of foetal head size than the BPD and its use in growth profile will give a better diagnosis of IUGR than the BPD in cases of dolicocephaly.

Head circumference is also correlated with true foetal head volume, and will thus allow one to accurately monitor the foetal head growth. The head

circumference is also an integral part of head to body ratio used in evaluating body proportionately. Mini et al (1983) made a diagnosis of IUGR in 79.4% using head circumference as a parameter.

3. Abdominal circumference

The abdominal growth is a thought to be affected early in IUGR due to depletion of glycogen stores in the liver and subcutaneous fat in the soft tissues of the abdomen as detected by Campbell. Mini et al (1983) reported an accuracy of 86.8% and Kurjak et al (1980) 82.3% cases of IUGR by this parameter.

Nelson et al (1980) performed a 2 stage ultrasound examination schedule as a screening procedure for SPD fetuses in 474 singleton pregancies. In the first stage CRL and BPD were measured for an accurate assessment of gestational age in the second stage at 34-36 weeks the abdominal area and abdominal circumference were measured and an accuracy of 61% and 83.7% respectively were reported.

4. Femur length

Crown rump length has been measured throughout pregnancy but this requires a compound scanner. With the changing position of the foetus and the curving of foetal spine, there is a limitation in measuring crown rump length. Femur length is a more easily reproducible parameter and can be measured throughout

pregnancy. It adds an important third dimension to the routinely used 2-dimensional parameters (Head circumference, abdominal circumference) and hence may give help in identifying the pattern of growth retardation. Length measurements can be useful to follow both antenatally and postnatally for assessment of IUGR and its effect.

Femur length is decreased in symmetrical IUGR while remaining unaffected in asymmetrical IUGR.

Ott (1985) and Hadlock et al (1985) have studied the role of FL to AC ratio as a method for screening IUGR. It has an advantage that it is independent of gestational age. Mean FL/AC ratio was significantly different for average for gestational age (AGA) (22.33±1.80%) and small for gestational age (23.34±1.89%) and large for gestational age (20.99±1.32%) fetuses.

5. Weight estimation

In the past in assessing IUGR, BPD was correlated with foetal weight but it was noted that error of prediction was 400 gm, the accuracy was much diminished with birth weights less than 2500 gm or greater than 4300 gm (Gibbons et al 1971).

Warsof et al (1977) reported a method in which computer assisted analysis of data from 85 patients was utilised to determine the best formula to

determine foetal weight from BPD, AC, TIUV. Of these AC correlated best and a multifactoral equation using AC + BPD was constructed in which foetal weight could be predicted to within 106 gm/kg.

Campbell and Wilkins (1975), Worsoff (1977), Poll and Kasky (1979), Bernhalz (1980), Ott et al (1981), Sampson et al (1982), Shephard et al (1982), O'Gardy (1983), Hadlock et al (1984), Seeds et al (1984), Pattenses (1985), have described a variety of parameters determined with ultrasound which can be used to predict foetal weight. Foetal weight below the 10th percentile for gestational age is the traditional standard for defining IUGR (Deter et al 1983). But the variabity by this measurement is 16-20% which is quite large and hence this measurement alone would falsely classify some growth retarded and some normal fetuses.

6. Combined measurements - Body proportionality

1) HC/AC

This was the first sonographic measure of body proportionality used to detect IUGR. Campbell in 1977 reported that the average value of this parameter decreases in an appropriamately linear fashion between 16 - 40 weeks.

In 568 normal pregnancies HC/AC ratio between 17 - 40 weeks found to be :

17 weeks - 1.18

29 weeks - 1.11

36 weeks - 1.01

39 weeks .96

In 31 small for date featuses studied HC/AC ratio was above the mean of the normal range.

Deter et al (1981) obtained a linear function HC/AC = 1.38 - 0.0123 (GA).

Mini et al reported in a study of 28 patients suspected of IUGR that a single elevated HC/AC was enough to diagnose asymmetrical IUGR. This measurement fails to detect symmetrical IUGR but 70% sensitivity rates have been reported for detecting asymmetrical IUGR.

Varma et al (1979) reported HC/AC as the most accurate predictor of IUGR 82.9% were diagnosed at 33% wks and 85.7% were diagnosed at 36-38 weeks. It also distinguishes between symmetrical and asymmetrical IUGR.

Wladimiroff (1978) measured HC/AC ratio in normal and 84 IUGR fetuses. The normal HC/AC ratio at 24 weeks and 41 weeks. 1.59 and 1.05 respectively. Faetuses with normal A/C AC was associated with early onset of symmetrical IUGR In IUGR foetuses with increased HC/AC ratio growth retardation appeared to start in the 3rd trimester.

Seeds et al (1985) predicted IUGR in 96% of cases by HC/AC ratio.

ii) HA/TA

Varma et al (1979) have examined HA/TA ratio in fetuses from 26-40 weeks, and reported 77.1% foetuses as having IUGR at 33 weeks while 82.9% were detected within 10 days of delivery.

iii) HA/AA

Varma et al (1979) measured this ratio between 26-40 weeks. The plotting of mean values showed a significant variability. Selbing et al (1984) has shown little use of this parameter in detecting IUGR.

iv) BPD^2/AA

Hadlock in 1983 evaluated the relation between FL/AC in detecting IUGR. This ratio will not detect symmetrical IUGR cases but was found to be abnormal in all cases of asymmetric IUGR. This ratio has an advantage of having normal range values that do not change with time after 22 weeks. The normal value for this ratio FL/AC X100 22 ± 2 a value greater than 24 indicates IUGR.

7. Total intrauterine volume

TIUV Gohari et al (1977) was the first to use this measurement for detecting IUGR because TIUV is co

composed of foetal volume, placental volume and amniotic fluid volume all of which are reduced in pregnancies affected by IUGR.

TIUV = LXTXAX.5233

Where L,T and A are the longitudinal transverse and anteroposterior diameters of uterus.

Hobbins et al studied 100 normal and 96 high risks patients of which 28 delivered small for date foetuses. They found that if TIUV was greater than 1.5 SD below the mean for gestational age all the foetuses born were SFD. If TIUV was between 1-1.5 SD, 15 were normal fetuses and 7 were growth retarded (symmetrical). If TIUV was within 1SD the resultant foetuses were appropriate for gestational age on birth.

In another study by Seeds et al (1984) he found that foetuses were at risk from IUGR if TIUV was below 2.5% confidence limit. When TIUV was below the 10% confidence limit, 41% cases of IUGR were diagnosed.

Initially study with this parameter showed promising results but later on it was found to be affected by technique, variable bladder fullness, uterine shape.

Hence Hadlock et al (1983) concluded that it was not an ideal measurement for detecting IUGR.

8. Oligohydramnios

A reduction of amniotic fluid is a common finding in pregnancies affected by IUGR. Manning (1984) and Seeds (1984) suggested using an estimate of amniotic fluid volume as a screening for IUGR. They observed that when the largest pocket of amniotic fluid is less than 1 cm there is a high probability (89.9%) of the foetus being growth retarded.

Philipsin et al (1983) associated IUGR with oligohyramnios and found that it tended to occur in young hypertensive gravid women whereas non oligohydramenos associated with IUGR tended to occur in gravit women with low pre pregnancy weight. Since oligohydromnios is also common in past dated pregnancies it is not therefore specific for IUGR. Nevertheless whenever one suspects oligohydrominos in patients with intact membranes, the possibility of IUGR is increased and follow up studies are recommended for monitoring foetal growth.

9. Placental grading

In 1977 Granum et al developed a placental grading system based on the distribution of calcium within the placental substance and the basal place. It was the grade-3 placenta which was thought to represent placental maturity.

Petrucha and Plott (1982) demonstrated that the incidence of various placental grades changes as a function of time and that only approximately 20% of normal patients will have grade-3 placenta at term. They also noted that it was rare to have grade-3 placenta prior to 36 weeks and in women with IUGR this finding is often noted.

Kazzi (1983) demonstrated that when grade-3 placenta is identified in the presence of foetal weight below 2.7 kg and or less than 36 weeks gestational age there is a 4 fold increase in IUGR in comparision with foetuses of the same size with placenta grades less than 3.

AIMS AND OBJECTIVES

1. In the present study it is intended to detect symmetrical and asymmetrical IUGR prenately by means of real time ultrasound by serial second and third trimester measurements of foetal growth parameters.

2. To detect the etiological factors responsible in IUGR.

3. To study the perinatal risks in the two patterns of IUGR (symmetrical and asymmetrical).

4. To study the outcome of labour in symmetrical and asymmetrical IUGR cases.

MATERIAL AND METHOD

MATERIAL AND METHODS

MATERIAL

The study was conductedon pregnant women which were clinically suspected to have IUGR . The patients were selected at random from the antenatal clinic and the maternity ward of M.L.B. Medical College, Jhansi.

The study on the IUGR group

This group included pregnant women who had :

1. In clinical evaluation the fundal height of the uterus did not correspond to the expected period of gestation (on the basis of LMP) being less by atleast four weeks.
2. History of previous growth retarded foetuses.
3. History of chronic hypertension, severe insulin dependent diabetes mellitus, renal disease.
4. Pre-eclamptic toxemia.
5. Severe anaemia.
6. Alcohal, tobacco chewing and excessive smoking.
7. Extremely poor weight gain.
8. Oligohydramnios.
9. Post-dates.

The IUGR foetus

This was defined on the basis of birth weight falling below the 10th percentile according to the intra-uterine weight charts of singh et al (1974) per Indian basis.

METHOD

All the pregnant women of the study group were carefully examined to detect any predisposing factor of IUGR such as :

PET

Hypertension

Heart disease

Systemic maternal disease

Intra-uterine infection

Severe anaemia

The ultrasound measurements

BPD, HC, AC, FL measurements in IUGR patients were made serially using real time sector scan philips SDR 1550 SD.

B.P.D.

The foetal head can be outlined from the first trimester and by the 3rd month the ventricular system can be seen and measured. In later pregnancy the foetal head is identified in trans-verse cross sections as a circle when flexed and as an eclipse when extended. Angle of inclination of the foetal head over the spine was determined by several long scanning. Transverse scans were then performed to get a horizontal section of the foetal head recognised by the midline echo, which demonstrates the cavum septum pellicidum, the thalamus and the sysvian, fissure. The widest foetal head diameter at right angles to the midline echo was

made from the outer table of the anterior skull to the inner table of the posterior wall by the electronic calipers.

Difficulty in measuring BPD is encounterned in :

1. When the head goes into the pelvis, the circle of the head may becone incomplete but if midline falx can be seen, measurement is still possible.

2. In Breech presentation the BPD appears to be smaller.

3. In premature rupture of membrane - BPD appears to be smaller.

Head circumference

Images of the foetal skull were obtained at the widest point which demonstrated the falx cerebri as a midline echo. The image was frozen. The head circumference was measured by tracing around the head by map measures.

Abdominal circumference

The lie and angle of the foetal abdomen was initially determined. The transducer was kept just below the foetal heart and then turned 90° to give transvere section at the level of umbilical vein as it enters the liver. The outer margin of the abdomen was measured using map measures (Method I).

Method - 2

Two diameter of the foetal abdomen were measured at right angles to each other and the AC $(D_1+D_2)X1.57$.

Femur length

The technique of measuring femur length involves the initial determination of the lie of the foetus. The transducer is then alligned along the caudal end of the foetal spine and then rotated through 45-60° away from the foetal abdomen until full length of the femur is visualized (Method-I).

Method - II

Alternately the transducer may be placed at right angles to the foetal spine and passed down the foetal spine maintaining this angle till the caudal end. Since the femur is usually flexed the transducer as then rotated to 30-45° towards the foetal abdomen until ful length of femur is visualized.

Rarely, the femur may be extended in which case the transducer is either rotated in a direction opposite to that of the foetal abdomen (Method-II) or rotated through more than 90° (Method-I).

Once the femur is localized, both ends of calcified diaphysial portion are defined. This can be achieved accurately if both the soft tissue of buttock and knee joint can be seen, when a clear image is obtained it is

freezed and with help of electronic calipers the calcified portions are measured.

Difficulty in measuring femur length is encountered in two situations :

1. Breech presentation with the foetus lying deep in the pelvis, the overlying limbs obscuring distal end of femur.

2. Femur persistantly pointing directly antero-posterior at the transducer.

<u>False shortening</u>

1. If measuring may result from longitudinal section.

2. If attempts are made to measure the shadow produced by the femur bone.

<u>False lengthening</u>

This occurs if the ossification centers of ilium or ischum are superimposed on femur. Also if knee is flexed then the tibio fibular complex is incorporated in the femur lengthening.

<u>Body proportionality</u>

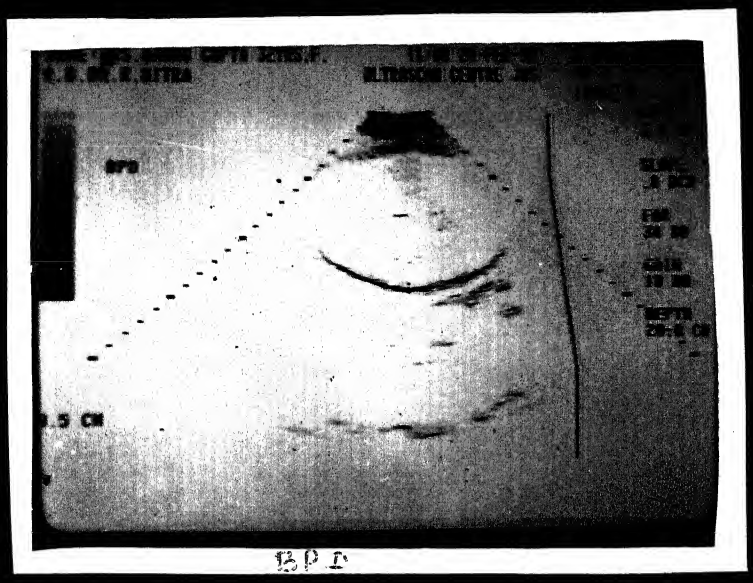
1. Head circumference/abdominal circumference ratio calculated from the two parameter.

2. FL/AC - ratio-calculated from the parameters foetal weight. Calculated from abdominal circumference.

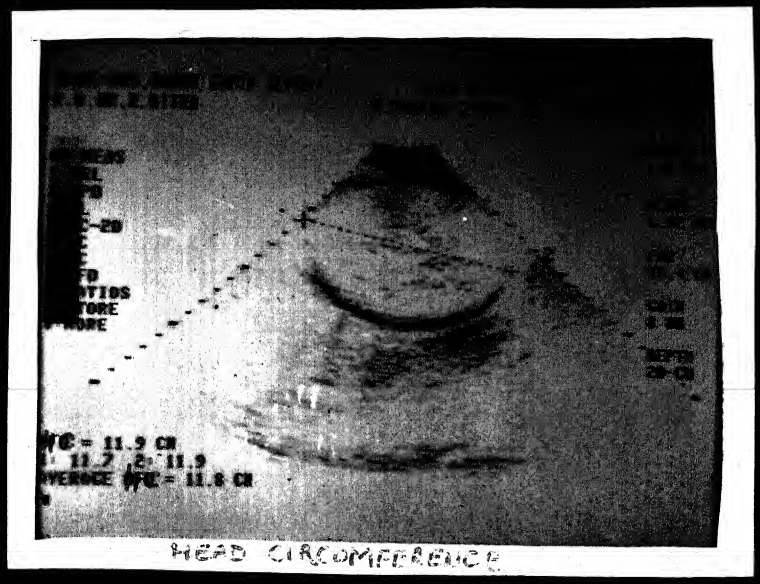
The pregnent women having IUGR were monitered carefully during labour and their behaviour in terms

of foetal distress, meconium aspiration, low apgar score and intra-uterine death noted.

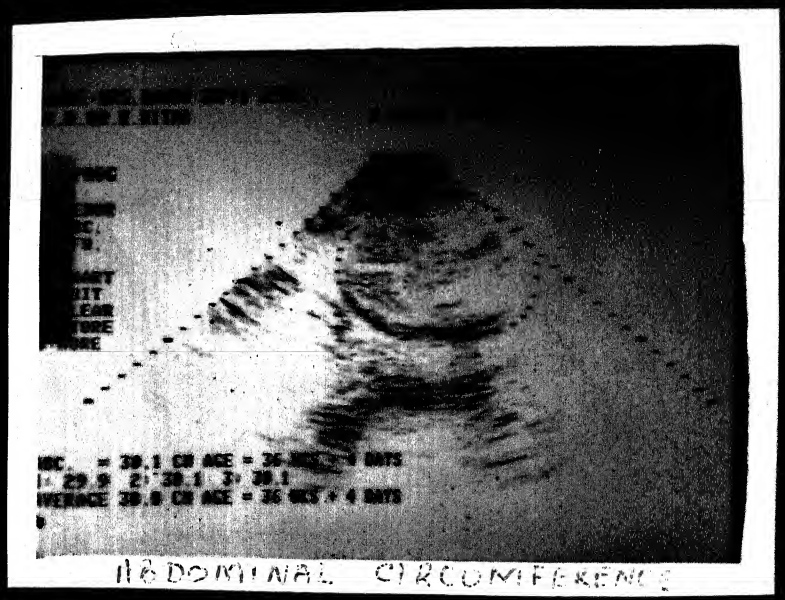
The outcome of labour, vaginal, forceps or LSCS was also noted.



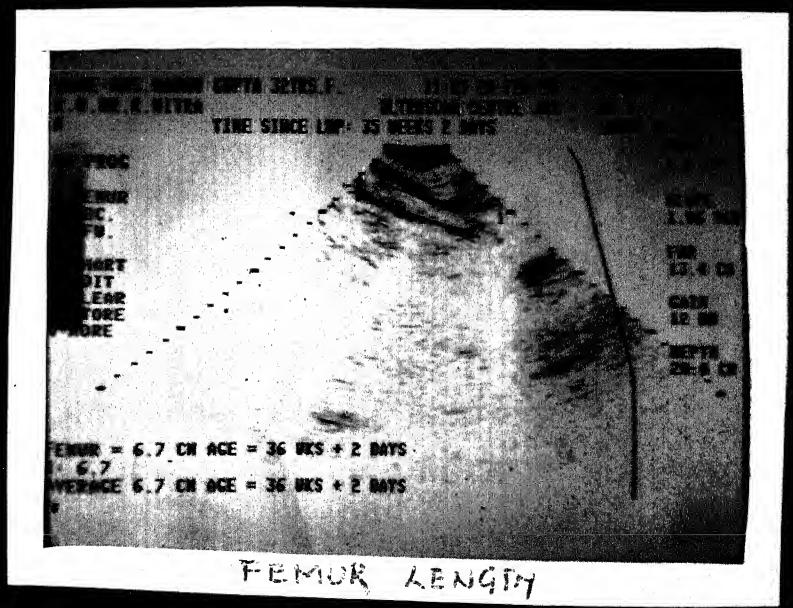
BPD



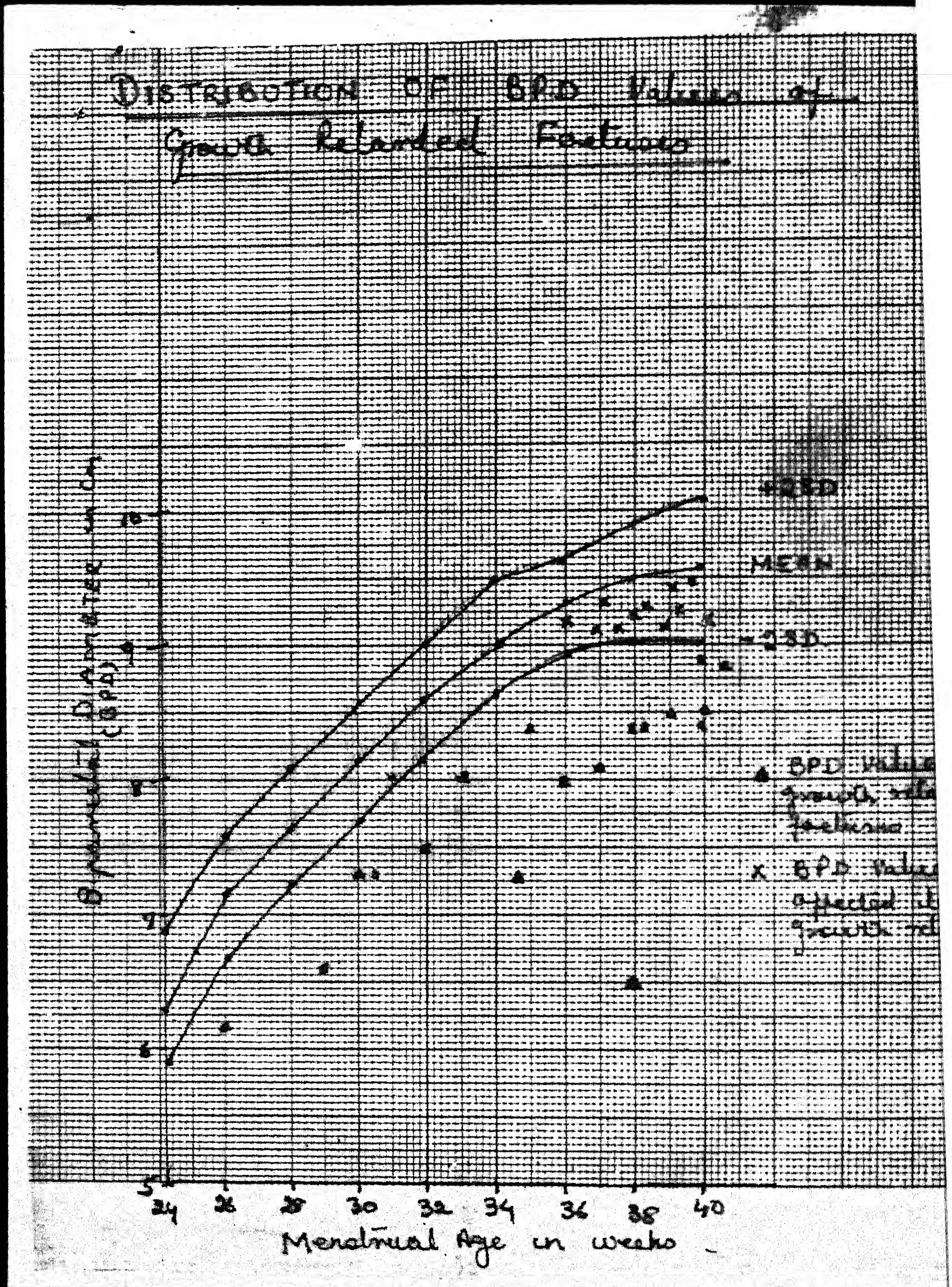
HEAD CIRCUMFERENCE



ABDOMINAL CIRCUMFERENCE



FEMUR LENGTH



DISTRIBUTION OF BPD Values of
Growth Retarded Foetuses
Biparietal Diameter in cm (BPD)
+2SD
MEAN
-2SD
Menstrual Age in weeks
24
26
28
30
32
34
36
38
40

FIGURE - 2

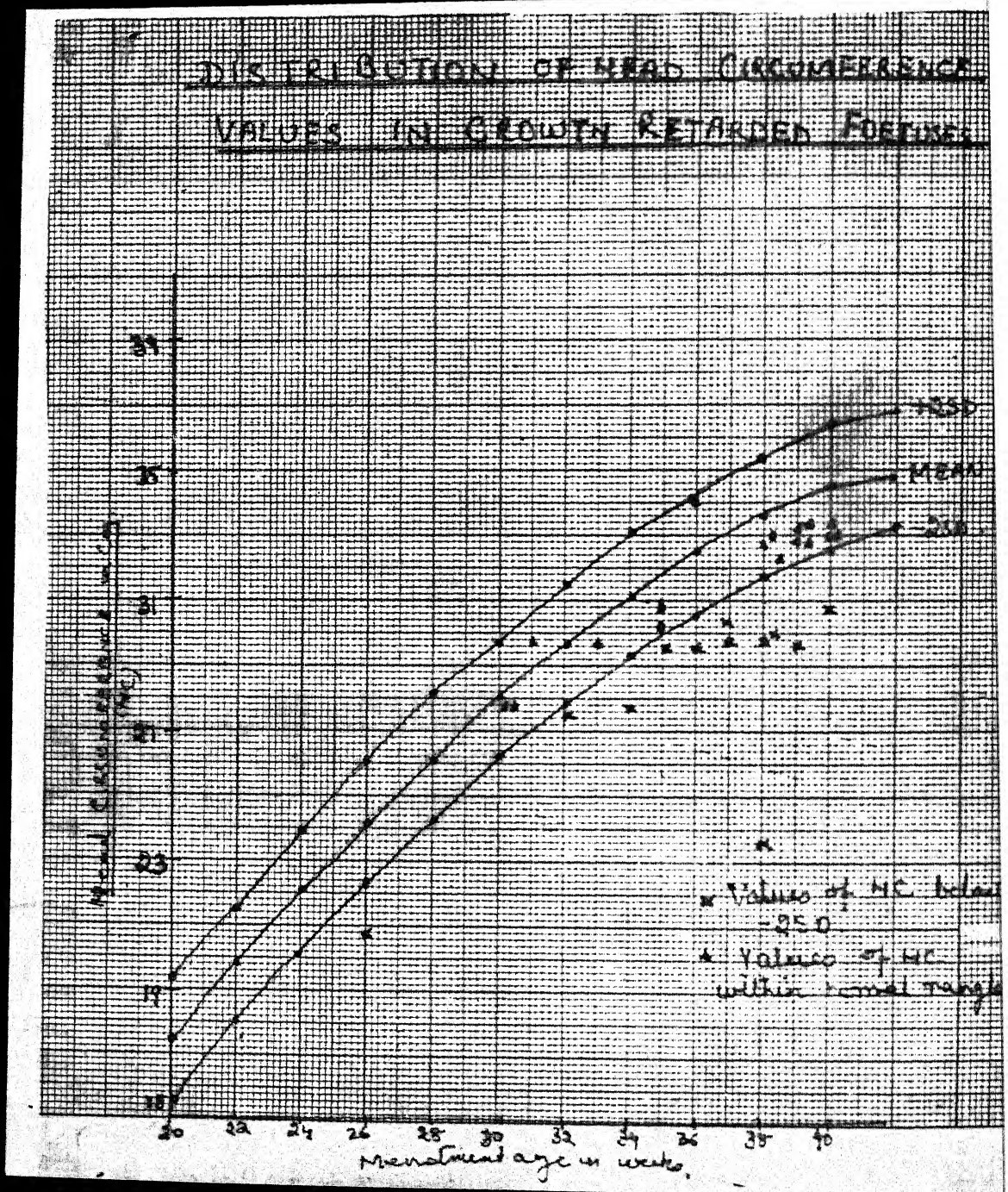

DISTRIBUTION OF HEAD CIRCUMFERENCE
VALUES IN GROWTH RETARDED FOETUSES
+2SD
MEAN
-2SD
31
27
23
19
15
20
22
24
26
28
30
32
34
36
38
40
Menstrual age in weeks.
* Values of HC below -2SD
+ Values of HC within 1 mm of -2SD

FIGURE - 2

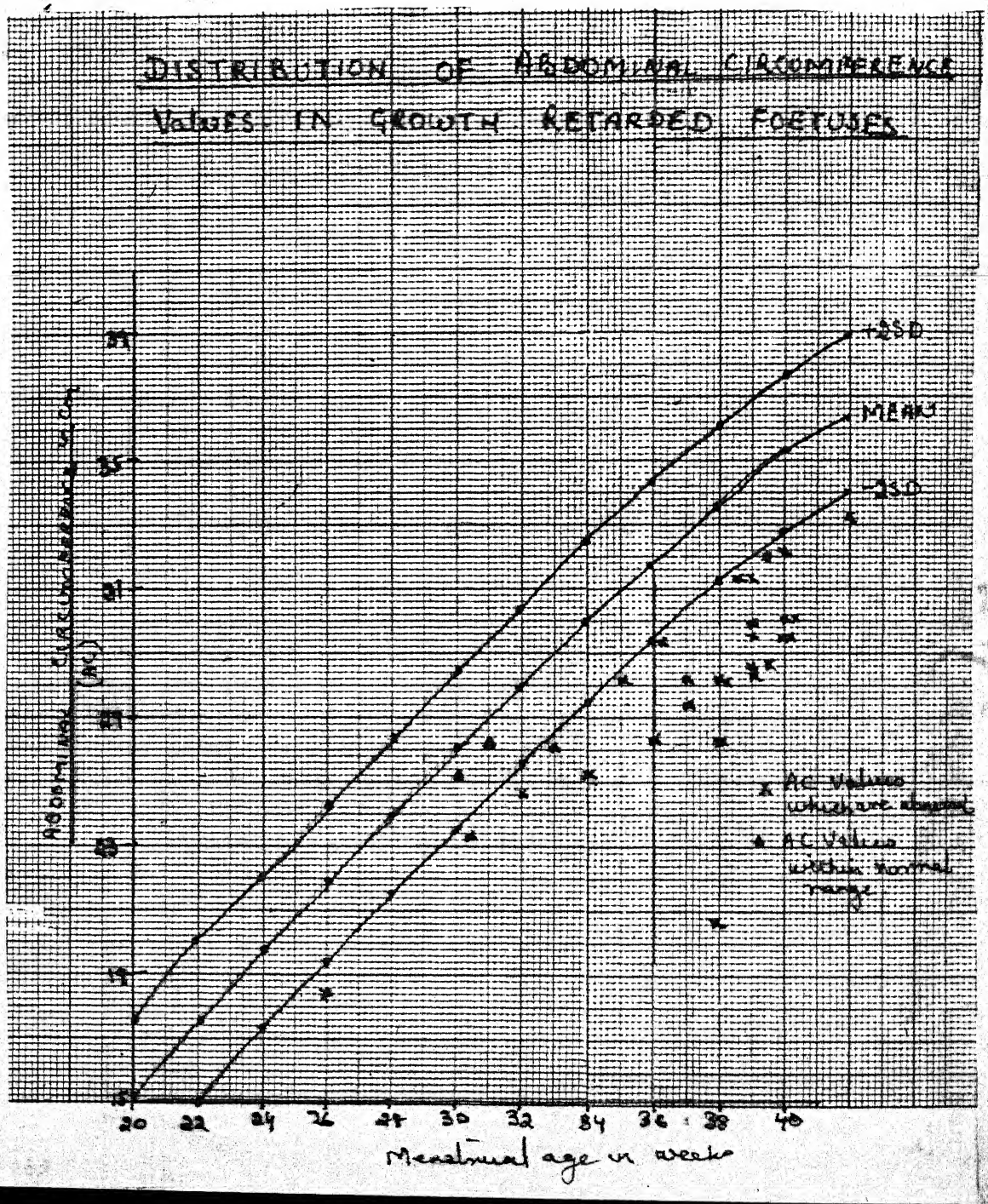

DISTRIBUTION OF ABDOMINAL CIRCUMFERENCE VALUES IN GROWTH RETARDED FOETUSES
ABDOMINAL CIRCUMFERENCE (AC)
+2SD
MEAN
-2SD
AC values which are abnormal
AC values within normal range
20
22
24
26
28
30
32
34
36
38
40
Menstrual age in weeks

FIGURE - 3

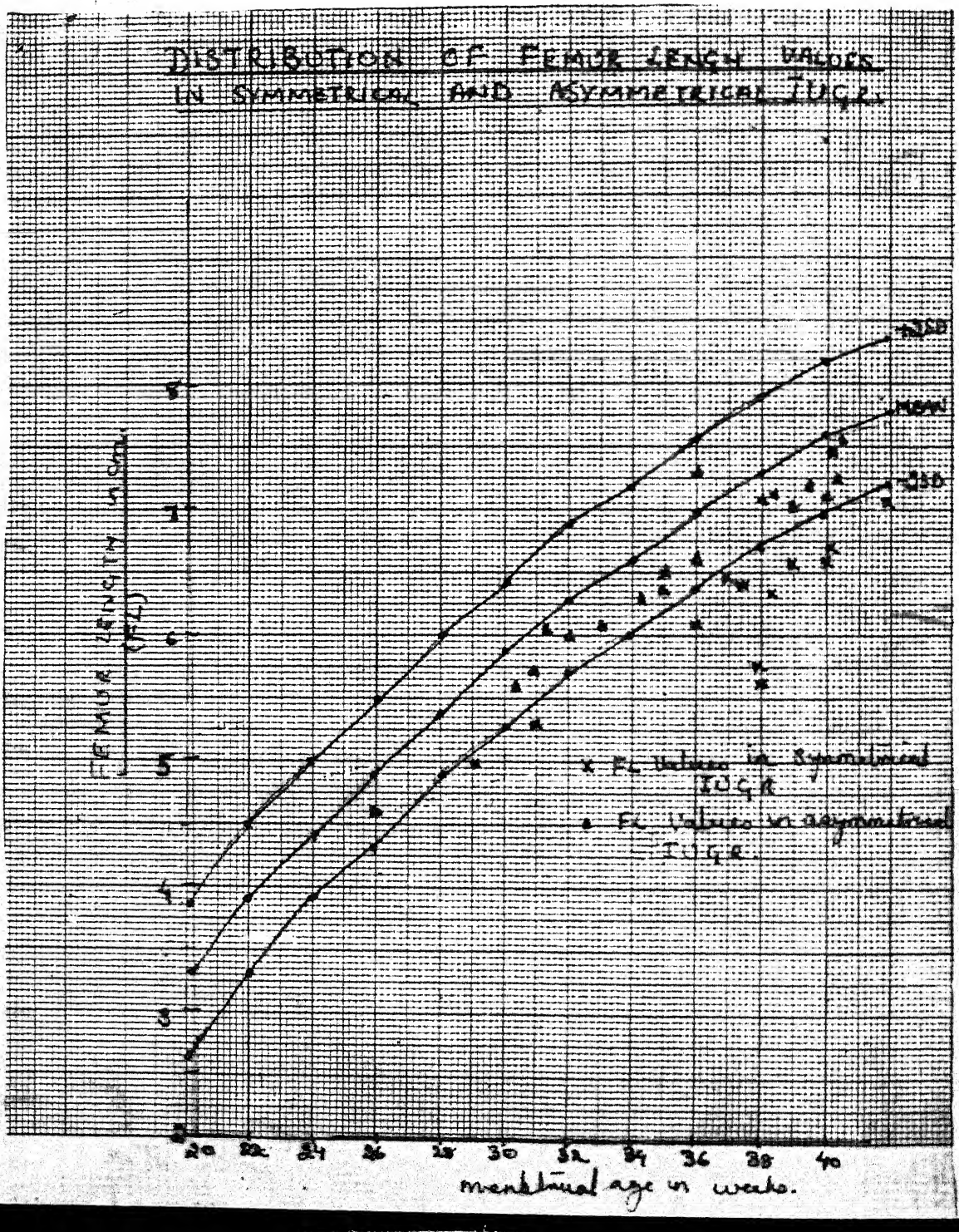

DISTRIBUTION OF FEMUR LENGTH VALUES IN SYMMETRICAL AND ASYMMETRICAL IUGR.
FEMUR LENGTH (cm)
8
7
6
5
4
3
2
+2SD
MEAN
-2SD
x FL Values in Symmetrical IUGR
• FL Values in asymmetrical IUGR
20 22 24 26 28 30 32 34 36 38 40
menstrual age in weeks.

FIGURE - 4

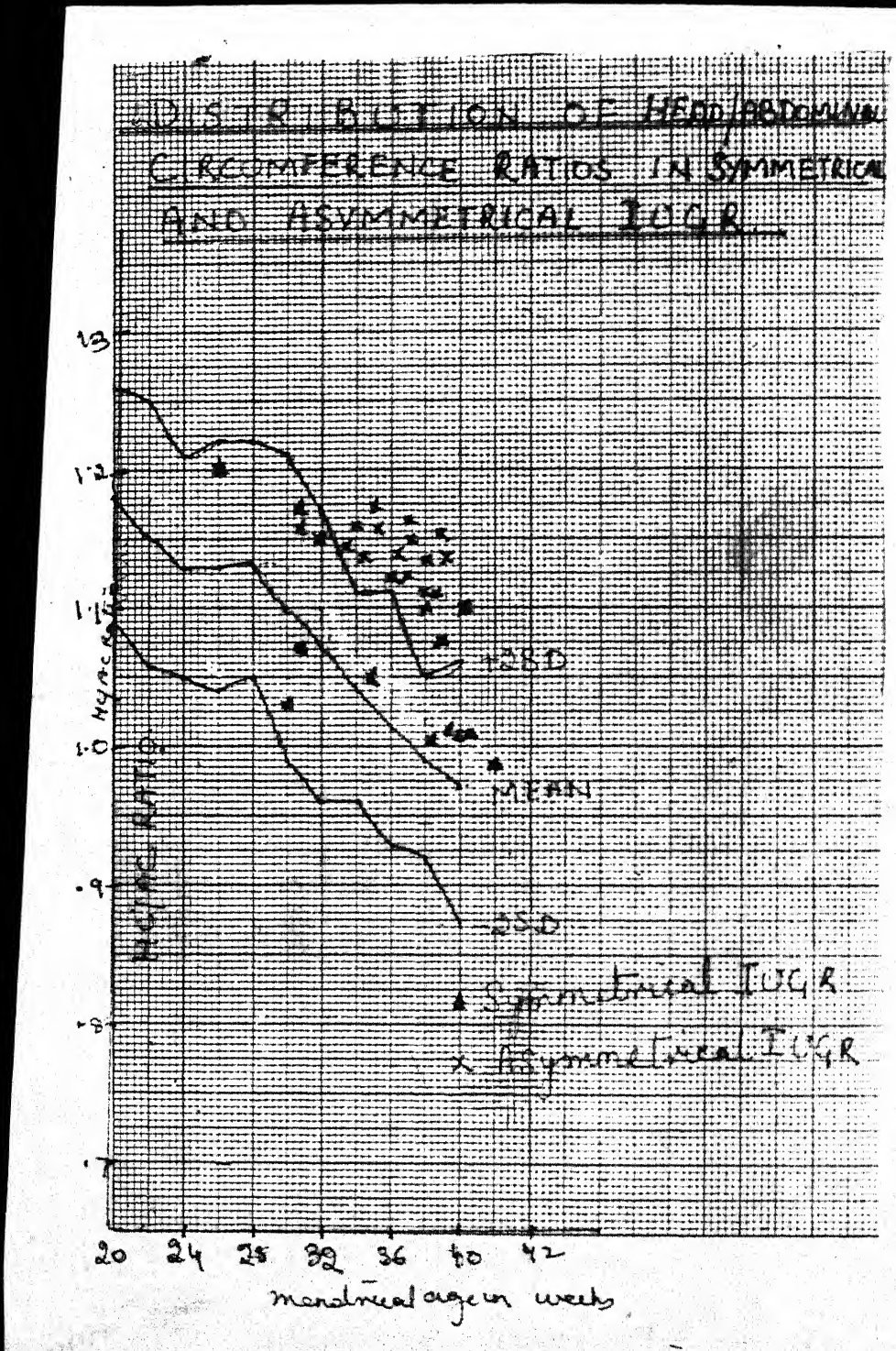

DISTRIBUTION OF HEAD/ABDOMINAL CIRCUMFERENCE RATIOS IN SYMMETRICAL AND ASYMMETRICAL IUGR
1·3
1·2
1·1
1·0
·9
·8
·7
Head/abdominal circumference ratio
+2SD
MEAN
-2SD
▲ Symmetrical IUGR
× Asymmetrical IUGR
20
24
28
32
36
40
42
menstrual age in weeks

FIGURE - 2

DISTRIBUTION OF FL/AC RATIO IN GROWTH RETARDED FOETUSES

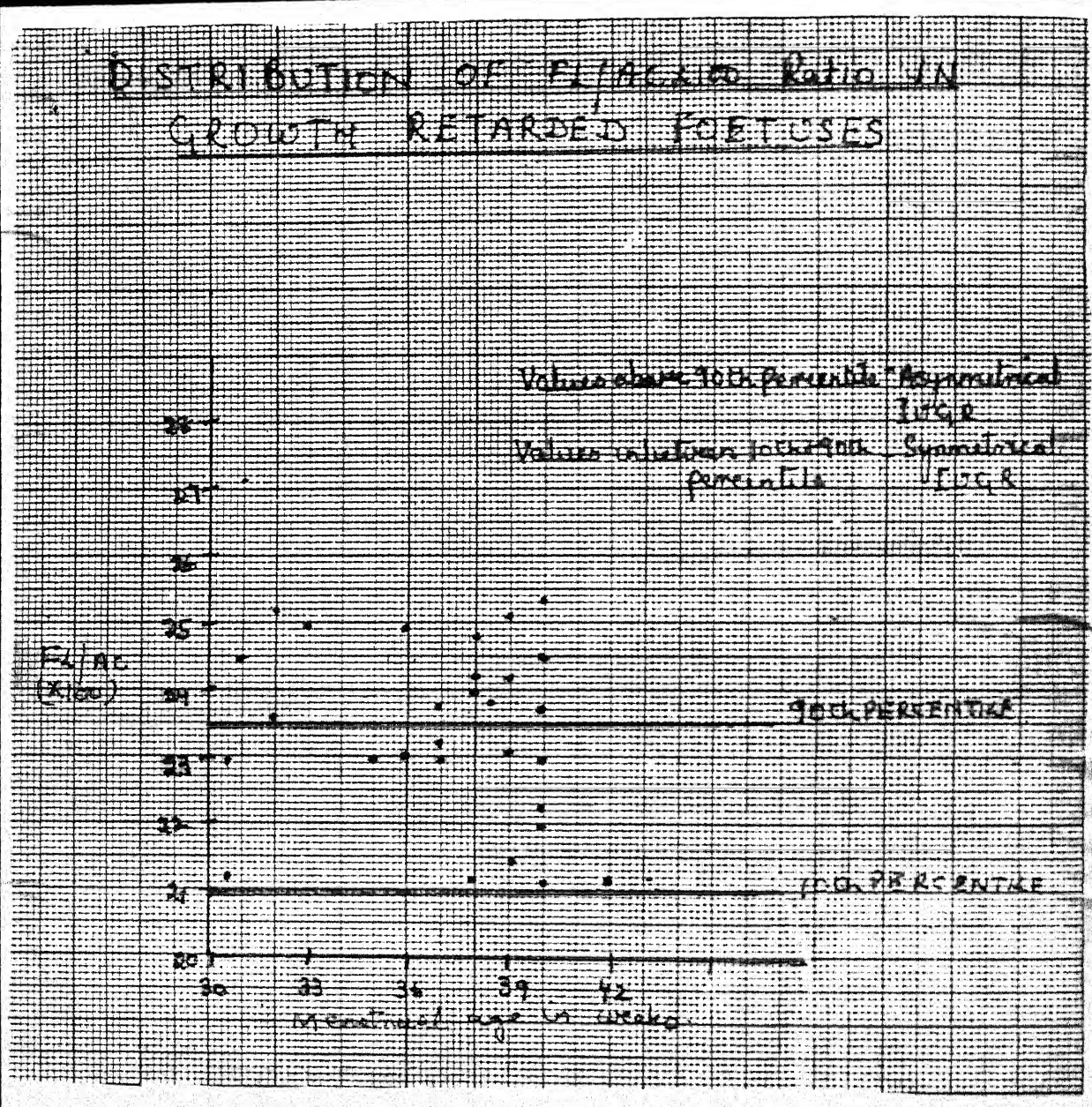


FIGURE 6

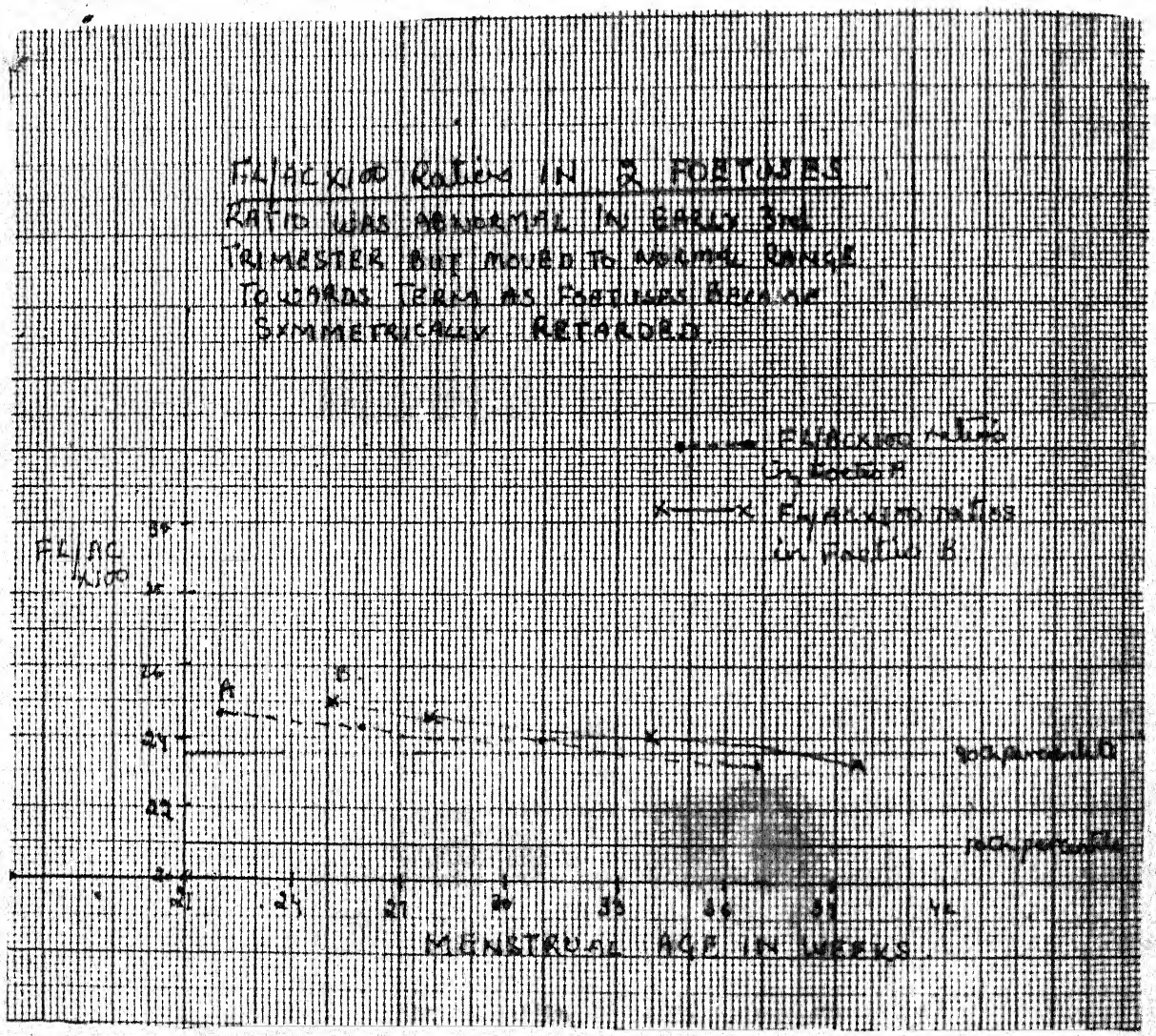

FEMUR/AC RATIOS IN 8 FOETUSES
RATIO WAS NORMAL IN EARLY 2ND TRIMESTER BUT MOVED TO ABNORMAL RANGE TOWARDS TERM AS FOETUSES BECAME SYMMETRICALLY RETARDED
FEMUR/AC RATIO
MENSTRUAL AGE IN WEEKS
A
B

FIGURE - 7

OBSERVATION

O B S E R V A T I O N S

Fortytwo cases with clinical suspicion of IUGR were studied of which 30 foetuses were actually IUGR on ultrasonic evaluation. Of the 30 foetuses, 25 foetuses were found to be small for data (SFD) at birth.

Further 10 foetuses were normal on ultrasonic examination and were declared normal at birth. However 2 foetuses found normal on ultrasonic examination later turned out to be IUGR at birth.

Various parameters were used to detect the IUGR foetuses ultrasonography like BPD, HC, FL, AC and estimated foetal weight and it was found that a single parameter did not detect all the cases of IUGR. Each parameter used singly was found to be abnormal in only a certain number of cases as given in table-1.

Table - I

Parameter	Between mean and -2 SD		Below 2 SD	
	No.	%	No.	%
BPD	12	40	18	60
HC	18	60	12	40
FL	18	60	12	40
AC	2	6.66	28	93.33
ETW	5	16.66	25	83.3

Results obtained to date indicate that a variety of parameters are affective in identifying normal growing fetuses. However when abnormal values are obtained this is not unequivocal evidence of a growth retarded fetus as such values are seen in a significant number of normal fetuses and vice versa. What may be rigid is a growth profile consisting of a set of parameters sensitive to different types of growth abnormalities. BPD, HC, AC, FL are made from the IUGR foetuses and are plotted as a scatter gram against the normal range (Fig. 1,2,3,4).

Some readings fell below the mean but within the normal range while some reading fell below the -2 SD limit. A definative diagnosis of IUGR was made in those cases whose readings fell below the 2 SD limit.

It was also observed that in cases with BPD and AC well below the normal range for gestational age, the femur length measurements were also found to be all significantly below the 2 SD limit. This represented a symmetrically retarded foetus.

In foetuses with AC below the 2 SD limit and BPD within normal range, the femur length measurements were also found to be within the normal range. This represented the asymmetrical IUGR.

More information was gained about the type of growth retardation by studying the relationship

between foetal head and body measurements like HC/AC and FL/AC. Asymmetrical growth retardation is manifested by a high foetal brain to liver ratio.

HC measurements were divided by AC measurements to obtain HC/AC ratio in all the IUGR foetuses. These values were plotted against normal values (Fig. 5). After 36 weeks when head circumference approximated the abdominal circumference the readings obtained were compared with the normal values and if the HC/AC was more than 2 SD above the expected value at that gestation a diagnosis of asymmetrical IUGR was made. If the value was between mean and 2 SD then a diagnosis of symmetrical IUGR was made.

This ratio detected 40% of symmetrical IUGR and 60% of asymmetrical IUGR i.e. table-II.

Table - II

Detection of the 2 type of IUGR by different parameters

	Symmetrical		Asymmetrical	
	No.	%	No.	%
HC/AC	12	40	18	60
FL/AC	14	46.66	16	53.33
FL	12	40	18	60
BPD	18	60	12	40

Similarly FL measurements were divided by AC measurements to get the FL/AC X100. This was plotted as a scattergram against the normal. It is clear from our results that FL/AC ratio is a relatively good

predictor of foetal growth retardation. Using the 90th percentile as the upper limit of normal, this ratio could detect 53.33% of growth retarded foetuses (table-II, Fig. 6). This is particularly noteworthy in comparision with the use of femur length alone which detected only 40% of growth retarded foetuses and required the knowledge of menstrual age.

Further it was observed that in two foetuses who had abnormal FL/AC ratios at early 3rd trimester, when scanned again before delivery were observed to have FL/AC ratio within the normal range but at birth were found to be severely symmetrically retarded (Fig.7).

On studying the etiology of the two types of IUGR it was observed that more than one cause might operate in a single case.

Table - III

Etiology	Symmetrical IUGR		Asymmetrical IUGR	
	No.	%	No.	%
Maternal hypertension	1	3.33	0	0
PET	1	3.33	6	20
Heart disease	0	0	0	0
Intrauterine infection	0	0	0	0
Systemic maternal diseases (Hepatitis)	2	6.66	1	3.33
Previous IUGR baby	1	3.33	3	10
Bad obstretical histemy	2	6.66	8	26.66
Severe anaemia	4	13.33	1	3.33
Congenital malfemation	0	0	0	0
Idigathic IUGR	3	10	3	10

All these patients were monitored during labour and the perinatal risks and labour outcome studied (table-IV).

Table - IV

Perinatal risk	Symmetrical No.	%	Asymmetrical No.	%
Foetal distress	2	6.66	10	33.33
Meconium aspiration	4	13.33	7	23.33
Low apgar score	7	23.33	10	33.33
IUD	4	13.33	0	0

Here again more than one risk might occur in a single case.

Lastly the labour outcome in the IUGR cases was studied (table-V).

Table - V

	Symmetrical No.	%	Asymmetrical No.	%
Spontaneour vag. delivery	8	26.26	6	20
Forceps	3	10	5	16.66
LSCS	1	3.33	7	23.33

Thus it was seen that maternal hypertension before 20 weeks of gestation, and idiopathic IUGR and severe anaemia, systemic malarial disease was more commonly associated with symmetrical IUGR while PPT, heart disease, bad obstritical history previous IUGR baby were associated with asymmetrical IUGR.

Perinatal problems

During labour and in the perinatal period the incidence of foetal distress, low (below 5/10) Apgar scores and meconium aspiration more commonly occured with asymmetrical IUGR (table-IV). There were 4 intrauterine deaths which occured in symmetrically growth retarded foetus, the cause of one was hepatic encepalopathy in mother and other severe anaemia. Their placentas on delivery were found to be abnormally small.

Study populations

To assess the efficacy of various parameters in detecting growth retardation, it is necessary to consider the experience of numerous investigations. To minimize confusion and optimize comparisions, the following data presentation procedure as suggested by Deter et al (1982). Using deter's standard protocal, the results were presented as a fraction of the base population and expressed as a percentage so that the sum always equal 100%. (TABLE VI)

Type I study population

The effectiveness of any parameter is best evaluated when it is applied to both normal and abnormal foetuses.

Type II study population

This represents a data presented only of foetuses with abnormal ultrasound parameters.

Table - VI

Standardized procedure for presenting results of studies in which ultrasound is used to detect normal and abnormal foetal growth

Type 1

$$\% \text{ CN} = \frac{\text{CN}}{\text{FP+CN+CA+FN}} \times 100 \qquad \% \text{ CA} = \frac{\text{CA}}{\text{FP+CN+CA+FN}} \times 100$$

$$\% \text{ FP} = \frac{\text{FP}}{\text{FP+CN+CA+FN}} \times 100 \qquad \% \text{ FN} = \frac{\text{FN}}{\text{FP+CN+CA+FN}} \times 100$$

Type 2

Incidence of normal foetuses having abnormal ultrasound parameters $= \text{nUSA} = \frac{\text{FP}}{\text{FP + CN}} \times 100$

Incidence of abnormal foetuses having abnormal ultrasound parameters $= \text{aUSA} = \frac{\text{CA}}{\text{FP + CA}} \times 100$

Type 3

Incidence of normal ultrasound parameters in abnormal foetuses $= \text{nFA} = \frac{\text{FN}}{\text{FN + CN}} \times 100$

Incidence of abnormal ultrasound parameters in abnormal foetuses $= \text{aFA} = \frac{\text{CA}}{\text{FN + CN}} \times 100$

Type 4

Incidence of normal fetuses having normal ultrasound parameters $= \text{nUSN} = \frac{\text{CN}}{\text{CN + FN}} \times 100$

Incidence of abnormal foetuses having normal ultrasound parameters $= \text{aUSA} = \frac{\text{FN}}{\text{CN + FR}} \times 100$

Type 5

Incidence of normal ultrasound parameters in normal foetuses $= \text{nFN} = \frac{\text{CN}}{\text{CN + FP}} \times 100$

Incidence of abnormal ultrasound parameters in normal fetuses $= \text{aFN} = \frac{\text{FP}}{\text{CN + FP}} \times 100$

N = Normal value

A = Abnormal value

CN = Number of correct diagnosis of normal foetuses = 10

CA = Number of correct diagnosis of abnormal foetuses = 25

FN = Number of abnormal foetuses = 2

Type III study population

Data referring only to foetuses classified as small for gestational age at birth.

Type IV and Type V study population

Refer to data from foetuses which had normal ultrasound parameters and which were declared normal at birth respectively.

Type I study population (the total population)

$$CN = \frac{CN}{Fp * CN + Cn + Fn} \times 100$$

$$= \frac{10}{5 + 10 + 25 + 2} \times 100$$

$$= 23.80\%$$

$$FP = \frac{FP}{FP + CN + CA + FN} \times 100$$

$$= \frac{5}{5 + 10 + 25 + 2} \times 100$$

$$= 11.9\%$$

$$CA = \frac{CA}{FP + CN + CA + FN} \times 100$$

$$= \frac{25}{5 + 10 + 25 + 2} \times 100$$

$$= 59.25\%$$

$$FN = \frac{FN}{FP + CN + CA + FN} \times 100$$

$$= \frac{2}{5 + 10 + 25 + 2} \times 100$$

$$= 4.76\%$$

Hence the correct diagnosis was made in 23.80% of normal foetuses and 59.52% of abnormal foetuses.

False positive cases reported were 11.9%. False negative cases reported were 4.78%.

Type 2 study population - i.e. foetuses with abnormal ultrasound parameters or ultrasonically IUGR group of foetuses were analysed. The results obtained were as follows :

The incidence of normal foetuses having abnormal ultrasound parameters

$$= \frac{FP}{FP + CN} \times 100$$

$$= \frac{5}{5 + 25} \times 100$$

$$= 16.66\%$$

The incidence of abnormal foetuses having abnormal ultrasound parameters

$$= \frac{CA}{FP + CN} \times 100$$

$$= \frac{25}{5 + 25} \times 100$$

$$= 83.33\%$$

Thus 83.33% of foetuses with abnormal ultrasound readings actually turned out to be IUGR at birth.

Type 3 study population - i.e. the foetuses which were IUGR as determined by birth weight after delivery.

The results obtained were as follows :

The incidence of normal ultrasound parameters in abnormal foetuses

$$= \frac{FN}{FN + CN} \times 100$$

$$= \frac{2}{2 + 25} \times 100$$

$$= 7.40\%$$

The incidence of abnormal ultrasound parameters in abnormal foetuses

$$= \frac{CA}{FN + CN} \times 100$$

$$= \frac{25}{2+25} \times 100$$

$$= 92.59\%$$

Type 4 study population - i.e. foetuses normal on ultrasound.

The results obtained were :

The incidence of normal foetuses having normal ultrasound parameters $= \frac{CN}{CN + FN} \times 100$

$= \frac{10}{10 + 2} \times 100$

$= 83.33\%$

The incidence of abnormal foetuses having normal ultrasound parameters $= \frac{FN}{CN + FN} \times 100$

$= \frac{2}{10 + 2} \times 100$

$= 16.66\%$

Type 5 study population (i.e. foetuses declared normal by birth weight after delivery).

The results obtained were :

The incidence of normal ultrasound parameter in normal foetuses $= \frac{CN}{CN + FP} \times 100$

$= \frac{10}{10 + 5} \times 100$

$= 66.66\%$

The incidence of abnormal ultrasound parameters in normal foetuses $= \frac{FP}{CN + FP} \times 100$

$= \frac{5}{10 + 5} \times 100$

$= 33.33\%$

DISCUSSION

D I S C U S S I O N

The use of real time ultrasound is becoming universal. It allows fast, reliable determination of gestational age and monitering of foetal growth. The reliability of prediction of gestational age and accuracy of detection of IUGR increases with an increase in the number of biological parameters that can be measured for estimation of gestational age and later for IUGR.

Various parameters used will detect two different kinds of IUGR. Symmetrical IUGR by definition involves a decreased head and abdominal circumference and a shortened femur length. In the present study 12 foetuses belonged to this category.

In contrast, the foetus with asymmetrical growth retardation tends to attain a normal BPD and FL while having a reduced abdominal circumference. Eighteen foetuses belonged to this category. It is known that peak femur growth is around the 20th week of gestation. Factors that hamper growth around this period of gestation result in symmetrically growth retarded fetuses and hence these foetuses are expected to have a decreased femur length.

In the present study conducted on 42 cases of high risk pregnancies (FL, BPD, AC, HC) of these 42

cases, 30 cases were found to have IUGR. The clinical suspicion was based on -

(a) The finding of reduced fundal height. It has been shown by earlier workers that a discrpency but 25% of normal growth pregnancies also manifest this (Daikoke et al 1979). Therefore the discrepency between clinical examination and ultrasonic evaluation in predicting IUGR can be attributed to the fall (1) in fundal height. (2) Another clinical criteria used was extremly poor weight gain. Maternal weight gain of less than 1lb/Wk is also present in 36% of normal growth pregnancies (Daiku et al 1979). Hence the criteria is of limited reliability.

At birth 25 cases were found to be small for date, 5 were appropriate for gestational age. A retrospective analysis of these cases revealed the etiological factors to be idiopathic and constitutional.

The only other study was done by Brein et al (1982) who reported similar results as in this study. Brein et al studied 126 patients with high risk pregnancy. He found that of 126 patients, 7 delivered small for dates. Symmetrical growth retardation was found in 6 while asymmetrical growth retardation was found in 1. However since he studied only 7 IUGR patients, no definative conclusion can be drawn from such a small sample.

Campbell in 1977 used HC/AC ratio to distinguish between symmetrical and asymmetrical growth retardation. The mean HC/AC ratio with 95% confidence limits was determined in 568 normal pregnancies from 17-41 weeks. The mean ratio was 1.18 at 17 weeks but decreased slowly until 29 weeks when ratio was 1.11, thereafter there was a sharp fall in the mean ratio to 1.01 at 36 weeks and 0.96 at 40 weeks. The HC/AC ratio was determined in 31 IUGR foetuses. The ratio was above the 95th contile limit in 22 (71%) of these foetuses.

Mini et al (89) found 64% of asymmetrical IUGR by HC/AC ratio above the 95% centile limit. Thus although the Indian babies are smaller in terms of head and abdominal size, the ratio of the 2 measurements is similar to these found by Campbell. The present study detected 60% of asymmetrical IUGR cases by this method (Table 7, Fig. 5).

Campbell and Mini et al found that chronic maternal malnutrition, heavy smoking, foetal infection and chromesomal abnormality typically caused uteroplacental blood flow, late in pregnancy usually were associated with asymmetrical IUGR. This was also seen in the present study. In our study we did not find any case with congenital abnormalities none of the patients were smokers (Table-III).

It was also found in the present study that a single elevated HC/AC was enough to diagnose asymmetrical IUGR and it should not be necessary to take multiple readings or do a serial measurements after 36 weeks to distinguish between symmetrical and asymmetrical IUGR as concluded by Mini et al (1984).

Hadlock et al (1983) evaluated FL/AC ratio as a predictor of IUGR in 30 cases using the 90th percentile (23.5) as the upper limit of normal, which resulted in the identification of 63% of the growth retarded fetuses. Because it is independent of menstrual age, this ratio proves most useful in evaluating high risk patients who present in the 3rd trimester of pregnancy with no dates. It is also of value in detecting growth retardation in patients with good menstrual history, since it was shown to become abnormal in asymmetrically growth retarded foetuses before the estimated weight fell below the 10th percentile.

In the present study by FL/AC ratio we detect 16 cases of asymmetrical IUGR 53.33% (Table II, Fig. 6) when the 90th percentile was taken as the upper limit. Two cases (Fig. 7) with values above the 90th percentile in mid pregnancy, had values within the normal range when measured ultrasonically within 10 days of delivery. Our impression was that this is the eventual compromise of bone growth in addition to the early involvement of

foetal fat and glycogen stores reflected in the early decreases in foetal abdominal circumference by prolonged exposure to the foetal growth retardation. Thus a ratio that returns to the normal range does not necessarily mean that the growth retardation process has been corrected and in fact may indicate increasing severity of the process resulting in a more symmetrically growth retarded foetus.

In our study, estimation of FL alone detected 40% of growth retarded foetuses (Fig. 4) whereas FL/AC ratio detected 53.33% of IUGR cases (Table II). This was also observed by Hadlock (1983) who detected 20% of IUGR cases by FL alone as against 63.3% of cases of FL/AC ratio.

BPD showed growth retardation in 60% of cases in our study (Table II, Fig. 1) whereas Campbell (1974), Whitham (1976), Mini (1983), Crone in 1977 made a correct diagnosis by this parameter in 81-91% of cases.

However Shall et al (1982) suggested the use of growth rate changes in BPD as a means of detecting foetal growth retardation in a patient presenting in the 3rd trimester with no dates but this method is limited by the shape changes and the significant biologic variability affecting the BPD in the third trimester besides the need for performing more than one examination.

In our study of 30 growth retarded foetuses, the abdominal circumference was the most sensitive indicator of IUGR - detecting 93% (Table I, Fig. 3) of cases as compared with Varma 1979, Mini 1983, who detected 90-95% of cases with this parameter. This is expected because the foetal fat stores and the gycogen stores in the liver are known to be affected early in foetal growth retardate.

Estimated foetal weight was also a relatively sensitive indicator of IUGR in this study detecting 25 cases (Table I). The slight understimation of foetal weight is due to the increase in density of growth retarded foetuses based on their decreased fat content.

The major limitation of detecting fetal growth retardation by these parameters - AC, BPD, HC/AC, FL and estimated foetal weight is the requirement that menstrual age must be unequivocal since the range of normal values for these factors changes with age.

Usher and Maclean and also Yerushalmy (1971) have shown that perinatal mortality is 8 fold increased in IUGR. It accounted for 25% of the perinatal mortality rate. These foetuses are also subjected to intrapartum and neonatal asphyxia (Low et al), hypoglycemia, hypocalcemia, polycythemia (Bend, 1971), Meconium aspiration, pulmonary haemorrhage, disorder

of temperature regulation, congenital malformation and long term morbidity in the form of impaired motor and cognitive function, lower IQ and neurological abnormalities are increased upto 20% (Wenner 1970), Galbirth et al have shown that 14.4% of mentally retarded children have suffered from IUGR at birth. Earlier the insult, longer the exposure, poorer the prognosis. Babies with asymmetrical IUGR are more prone to have foetal distress in labour, lower Apgar scores, and more frequent operative deliveries as studied by Campbell and Mini et al. This was also observed in the present study (Table IV & V). This is because the foetus with asymmetrical IUGR suffers from a state of chronic hypoxia which during labour becomes acute, leading to foetal distress, meconum aspiration and their sequaelae. Intrauterine death is more frequently associated with symmetrical IUGR because of the longer exposure to the result.

Comparision of results of present study with results obtained by other workers

	Campbell	Mini et al	Varma	Hadlock	Present study
BPD	86%	89%			60%
AC	-	90%	95%	-	93%
FL	-	-	-	20%	40%
FL/AC	-	-	-	63%	53.33%
HC/AC	71%	64%	-	-	60%

It is clear from our results that detection of foetal interauterine growth retardation is possible with the use of standard parameters, BPD, AC, HC/AC, FL estimated foetal weight in patients whose dates have been established early in pregnancy. FL/AC ratio is also added for sonographic detection of IUGR as this -

(a) Ratio is not dependent on knowledge of the true gestational age.

(b) This ratio can detect early indications of foetal growth retardation before the foetal weight has fallen below the 10th percentile thereby allowing early therapeutic measures.

(c) This ratio represents a relation between weight and height which can be measured in postnatal life as the ponderal index to evaluate neonates for signs of growth retardation.

$$PI = \frac{\text{Weight}}{\text{Length}^3} \times 100$$

Follow-up studies of growth retarded infants were done by Fancourt et al (1976). Small for date babies who were measured antenatally by serial cephalometry and who were examined at a mean age of 4 years have shown that the foetus with the longest period of growth retardation (the Law growth profile group) retained the somatic defecient in height, weight and to lesser extent head circumference. Further these infants had

significantly reduced development quotient scores as assessed by Ruth Griffith scale.

CONCLUSION

C O N C L U S I O N

Ultrasound plays an eminent role in the field of obstetrics. An accurateprediction of gestational age and assessment of foetal growth is an important diagnostic use of ultrasound. It has been increasingly recognised that an early diagnosis of IUGR enables timely intervention and hence influences the ultimate foetal outcome.

The study was conducted on 42 pregnant women with a clinical suspecion of IUGR. These were ultrasonographycally studied by BPD, AC, HC, FL measurements to differentiate between symmetrical and asymmetrical IUGR.

The data obtained was analysed and the following conclusions were drawn :

1. Role of identification of women who are at a risk of delivering a growth retarded foetus since 2/3rd of all IUGR fetuses will come from this population.
2. 1/3rd of all IUGR fetuses will be born to patients with no high risk factor for IUGR, for this reason one should analyse the foetus for evidence of IUGR in all obstretic sonograms regardless of the reason for study.

3. Normal ranges of foetal parameters used to detect IUGR change with advancing age, hence it is imperative especially in high risk patients to establish gestational age early in pregnancy.

4. Two types of growth retardation are studied - symmetrical and asymmetrical.

5. A single parameter will not detect both forms of growth retardation since a symmetrically retarded foetuses will have all parameters below -2 SD of mean whereas in asymmetrical retardation head and length are unaffected. Hence the need for multiple parameter study.

6. BPD, FL, AC values are significantly below -2 SD in symmetrical IUGR but are within normal range in asymmetrical IUGR.

7. A single elevated measurement of HC/AC ratio above 2 SD indicates asymmetrical IUGR.

8. FL/AC ratio is an age independent parameter and can be of use when dates are not confirmed. Values above 90th percentile detect asymmetrical IUGR.

9. A correct diagnosis of IUGR was made in 83.33% cases.

10. Of the 25 IUGR foetuses as declared after delivery abnormal ultrasonic measurements were obtained in 92.50%.

11. The parameters used to detect asymmetrical IUGR do not become abnormal until 30 weeks. Therefore in high risk patients examination of patient is done every 4 weeks till delivery. If IUGR is found the internal between scans is 2 weeks.

12. Symmetrical IUGR results from an insult early in pregnancy whereas asymmetrical IUGR results from placental insufficiency after about 30 weeks.

13. Asymmetrical IUGR is associated with higher perinatal risks like low (< 5/10) apgar score, meconium aspiration and foetal distress whereas intrauterine death is more commonly associated with symmetrical IUGR.

Hence we see that with the use of ultrasound the problem of estimating gestational age and diagnosing IUGR no longer frustates obstreticians. None of the parameters individually suffice but a combination of various parameters complement each other and provide a more complete profile for the assessment of both types of foetal growth retardation although a single HC/AC and FL/AC value is sufficient to detect asymmetrical IUGR.

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